Fission Fragment Distributions and Delayed Neutron Yields

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Recently a renewed interest in photonuclear processes has appeared. It is motivated by a number of different applications where progress in compact, reliable and high intensity electron accelerators was awaited. Some of these applications as radioactive ion beam (RIB) production, non-destructive characterization of waste barrels and detection of nuclear materials require a good knowledge of fission fragment distributions from photon induced fission. For most of the actinides these distributions are well known for neutron-induced fission, what is not the case for photon-induced fission. A companion paper describes developments and testing of the new photonuclear activation data library for CINDER'90, which also needs fission fragment distributions from photo-fission.

In this work we use the GSI fission-evaporation code which is known to give good results for the spallation process, where during the de-excitation process the nucleus looses its energy via evaporation and/or fission. In the case of photo-fission, the physics model is divided into two parts: the input channel with the photon absorption and nucleus excitation, and the output channel, that is the nucleus de-excitation. The nucleus excitation by photon is based on the giant dipole and giant quadruple resonances. The absorption cross section is the sum of these components, each of them determined from empirical systematics. The nucleus de-excitation is achieved with an independent code based on a statistical model, where fission is in a direct competition with particle emission. In other words, the complete code provides neutron (proton) emission and fission cross sections, and also fission yields. Multi-chance fissions are also taken into account.

The goal of our study is twofold:
a) we test the validity of the GSI fission-evaporation codes to predict photo-fission fragment distributions and, consequently, to characterize the corresponding delayed neutron yields;
b) we try to establish some systematic relationship with neutron induced fission at similar excitation energies.

By comparing our predictions for the U-235, U-238, and Pu-239 nuclei to the corresponding experimental data and other model calculations or library evaluations we conclude that the GSI fission-evaporation model is a powerful tool to describe photo-fission fragment distributions. Consequently, delayed neutron calculations also agree rather well with existing experimental data. On the other hand, we found some discrepancies for the particle emission and fission cross sections even though the total photon-induced absorption cross sections were well reproduced. These discrepancies depend on the incident photon energy and on the target nucleus. We believe that the major reason is the difficulty to get the right competition between evaporation and fission. We also aimed in showing the systematic similarity between neutron and photon-induced fission, but from this preliminary study no clear conclusions can be drawn at the moment.

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